

Validation of the Dual Pol Quantitative Precipitation Estimation (DP QPE) Algorithm

March 2011

NOAA/NWS/OHD - Mark Fresch, Jim
Ward, Dennis Miller, and Dan Stein

Outline

- Background
- Validation of new adaptable parameters for one rate equation, $R(Z, Z_{dr})$
- Validation of new logic to handle partial beam blockage (PBB)
- Attenuation/Non-uniform Beam Filling (NBF)

Background

Starting in May 2010, evaluation of algorithm performance on KOUN uncovered the following issues (among others; ref. to R. Lee):

1. DP QPE rate equation for rain, $R(Z, Z_{dr})$, is underestimating, particularly in tropical cases, e.g. the 14 June '10 OKC flash-flood
 - NSSL provided science fix - new adaptable parameters for $R(Z, Z_{dr})$
 - OHD implemented and validated – results shown here
2. DP QPE algorithm logic to handle partial beam blockage results in ineffective use of hydro-classes for even small % blockages
 - NSSL provided science fix – new logic
 - OHD implemented and completed preliminary validation – results shown here

Background cont'd

3. Attenuation/Non-uniform Beam Filling (NBF) is not uncommon (in OK in Spring) and causes underestimation - even zero rates
 - NSSL provided initial science fix involving four algorithms
 - OHD in process of validating

Since Zdr calibration issue was discovered, in order to do the validation in a timely manner, we've applied a static Zdr bias correction to past KOUN cases. The correction was computed independently for each case. The alternative would have been to wait for the issue to be corrected before any data was deemed useful for algorithm validation.

1. Validation of new $R(Z,Zdr)$ parameters

- NSSL proposed new default adaptable parameters for the rate equation using Zdr , i.e. $R(Z,Zdr)$, in order to add more weight to Zdr
 - Expected result - reduce underestimation in 'tropical' cases with little or no change to 'continental' cases
- OHD validation methodology - compared non-zero estimates from DP QPE to gauges for storm totals and computed statistics (subset shown here)
 - Developed a tool to automatically compare DP QPE estimates to gauge data archived on the internet

1. Validation of new R(Z,Zdr) parameters OHD validation methodology, cont'd

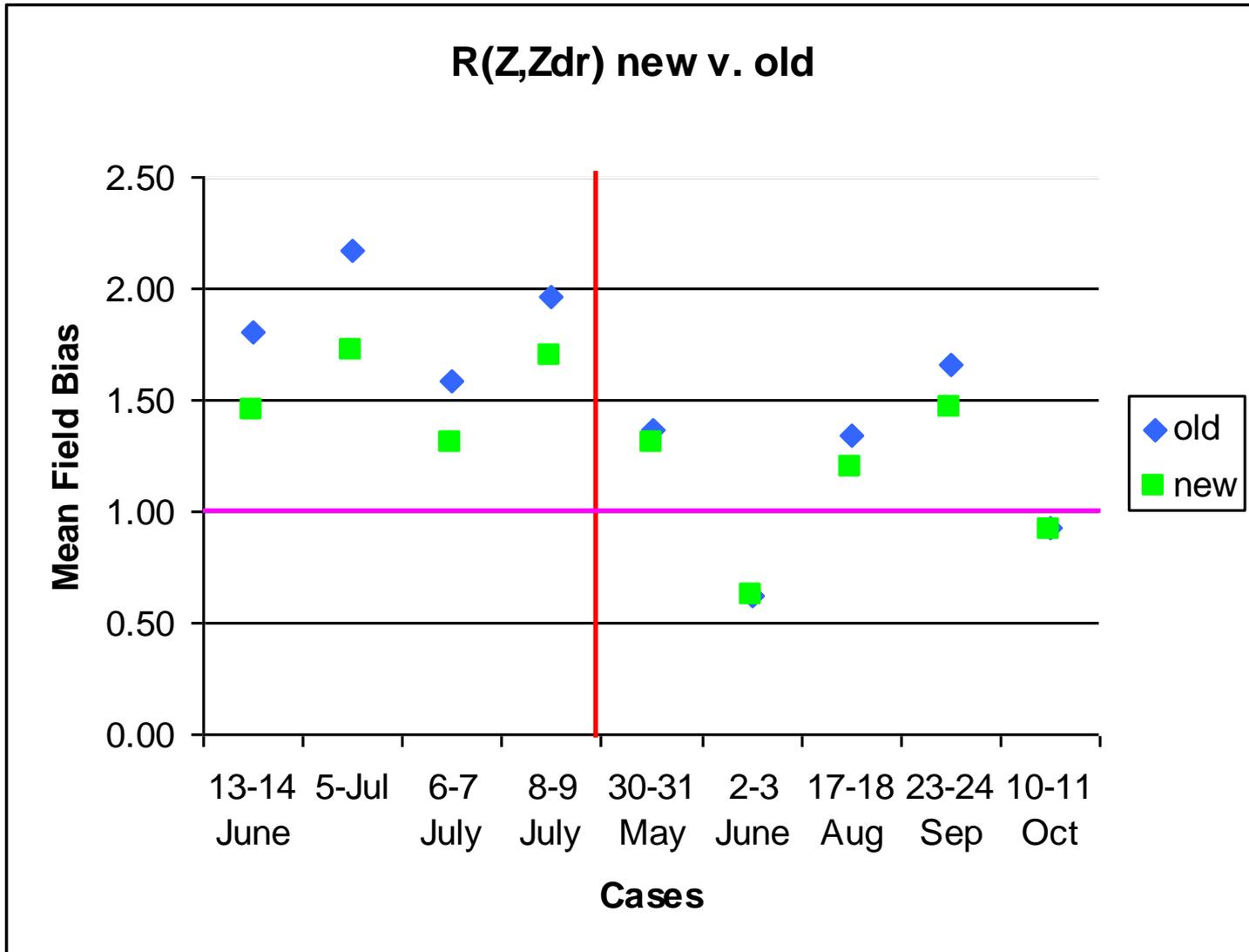
- Gauges are from OK mesonet and micronets - didn't use gauges in non-terrain based blockages (water towers, etc.) and tried to eliminate gauges in clutter-contaminated areas
- 4 'tropical' cases (i.e. rain events) and 5 'continental' cases all 2010
- Ran each case twice with: 1) old parameters and 2) new parameters
- Used 0% blockage to circumvent poor baseline partial beam blockage logic (good assumption for KOUN) & avoided gauges within blocked radials
- Stats: Storm totals – mean-field bias, correlation coefficient & fractional bias
 - No hourly results because storm total results have obvious trend

Cases & # of gauge-radar pairs

DP QPE Validation new v. old R(Z,Zdr)	# gauge-radar pairs
Cases - start date	storm-total
13-Jun-10	133
5-Jul-10	79
6-Jul-10	99
8-Jul-10	114
30-May-10	96
2-Jun-10	61
17-Aug-10	142
23-Sep-10	121
10-Oct-10	60
Totals	906

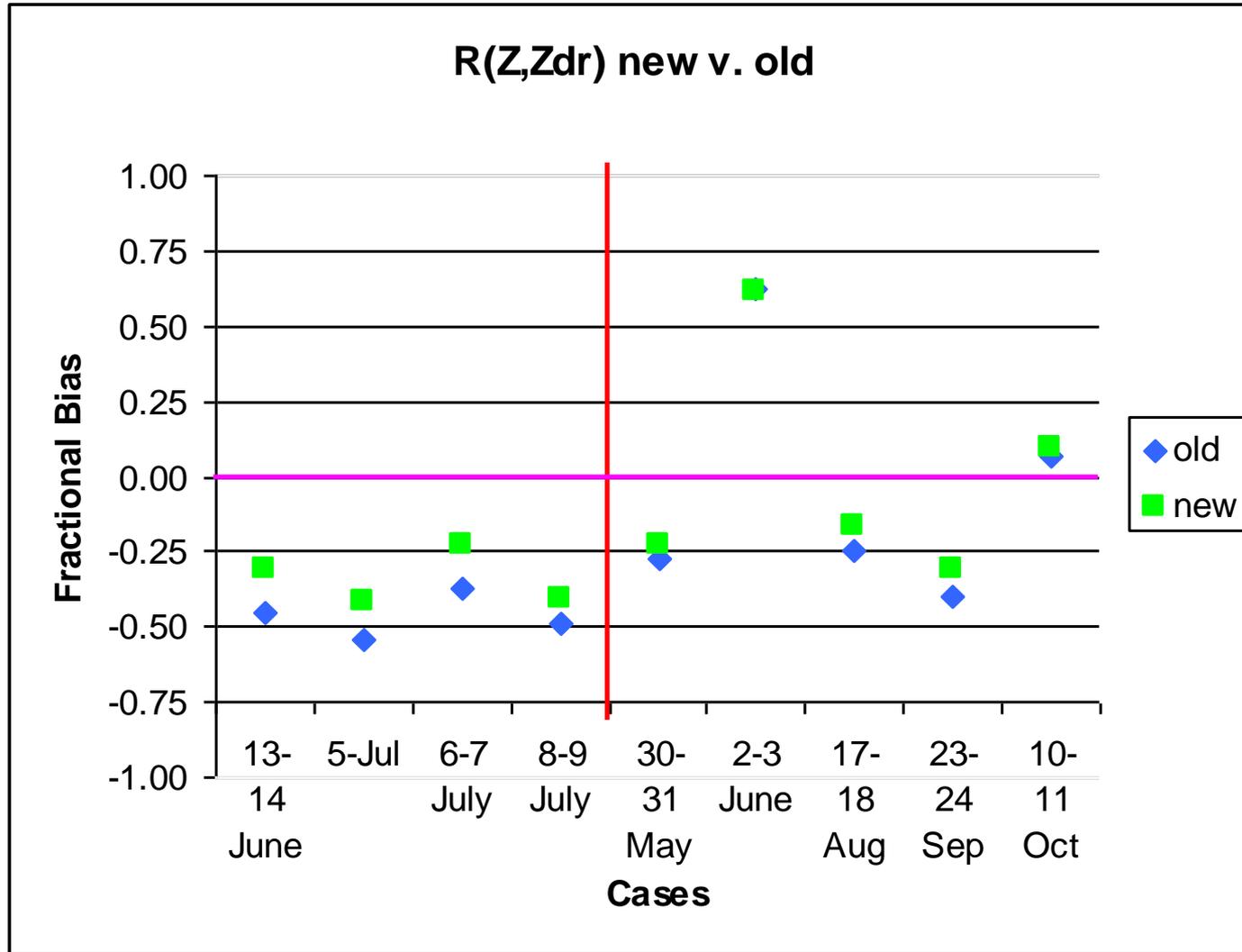
Number of gauge-radar pairs are from old parameters, and new parameter had the same number of pairs +/- 2. Differences are due to using only non-zero DP QPE values. Tropical cases are in blue font.

Storm Totals – Mean Field Bias



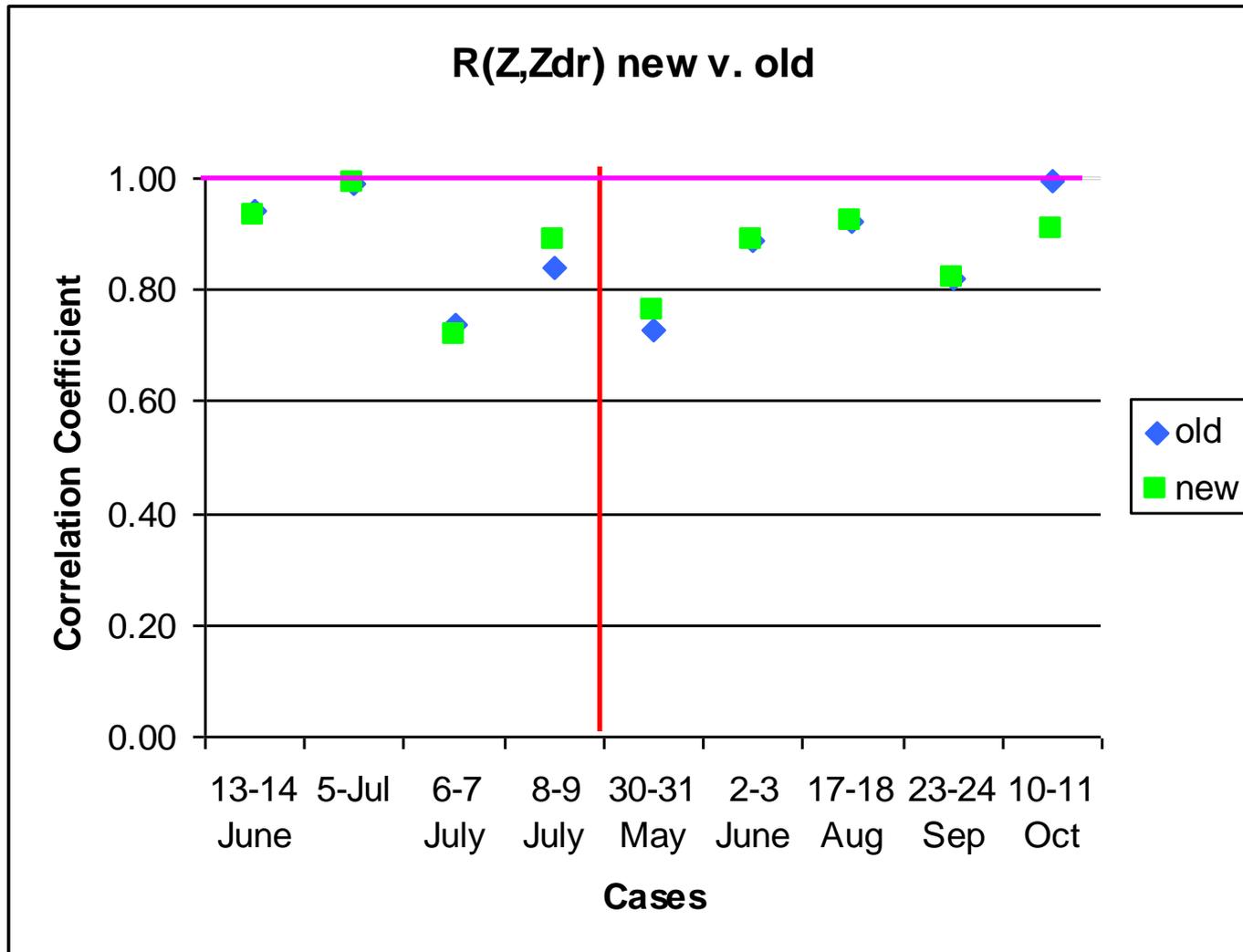
The best mean field bias value is 1.0 (magenta line). Great (lesser) values indicate underestimation (overestimation). Tropical cases are left of the red vertical line. ⁸

Storm Totals – Fractional Bias



The best fractional bias value is 0 (magenta line). Negative (positive) values indicate underestimation (overestimation). Tropical cases are left of the red vertical line.

Storm Totals – Correlation Coefficient



The best correlation coefficient value is 1.0 (magenta line). Tropical cases are left of the red vertical line.

New R(Z,Zdr) results & conclusions

- **Results - the new (v. old) default adaptable parameters reduced bias, as expected**
 - Tropical
 - Improved mean field bias and fractional bias
 - Similar correlation coefficients
 - Continental
 - Slight improvement in mean field bias and fractional
 - Similar correlation coefficients
- **Conclusions**
 - Consensus of algorithm experts – accept new adaptable parameters
 - Still significant underestimation, especially in tropical cases
 - Need to do more comparisons after Zdr calibration issue is fixed

2. PBB Validation Methodology

- NSSL proposed new logic to handle PBB within the DP QPE Alg
 - Old PBB logic does not utilize full set of hydro-classes when the beam is blocked just 0.5% or more
 - New PBB logic maintains the hydro-class based rates for blockages of $< 20\%$
- Preliminary validation – Using data from KOUN, compared non-zero DP QPE output to gauges for storm totals and hourly time increments and computed many statistics (subset shown here)
 - Expected result – Since KOUN has very little blockage, the new PBB logic improves DP QPE or does no harm, i.e. DP QPE performance with the new PPB is at least as good as with the old PBB
- Secondary validation – TBD – Will validate new PBB using data from field sites, including Dual Pol Beta Test sites, with complex terrain around the radar site, such as Phoenix, AZ, pending funding

2. PBB Validation Methodology, cont'd

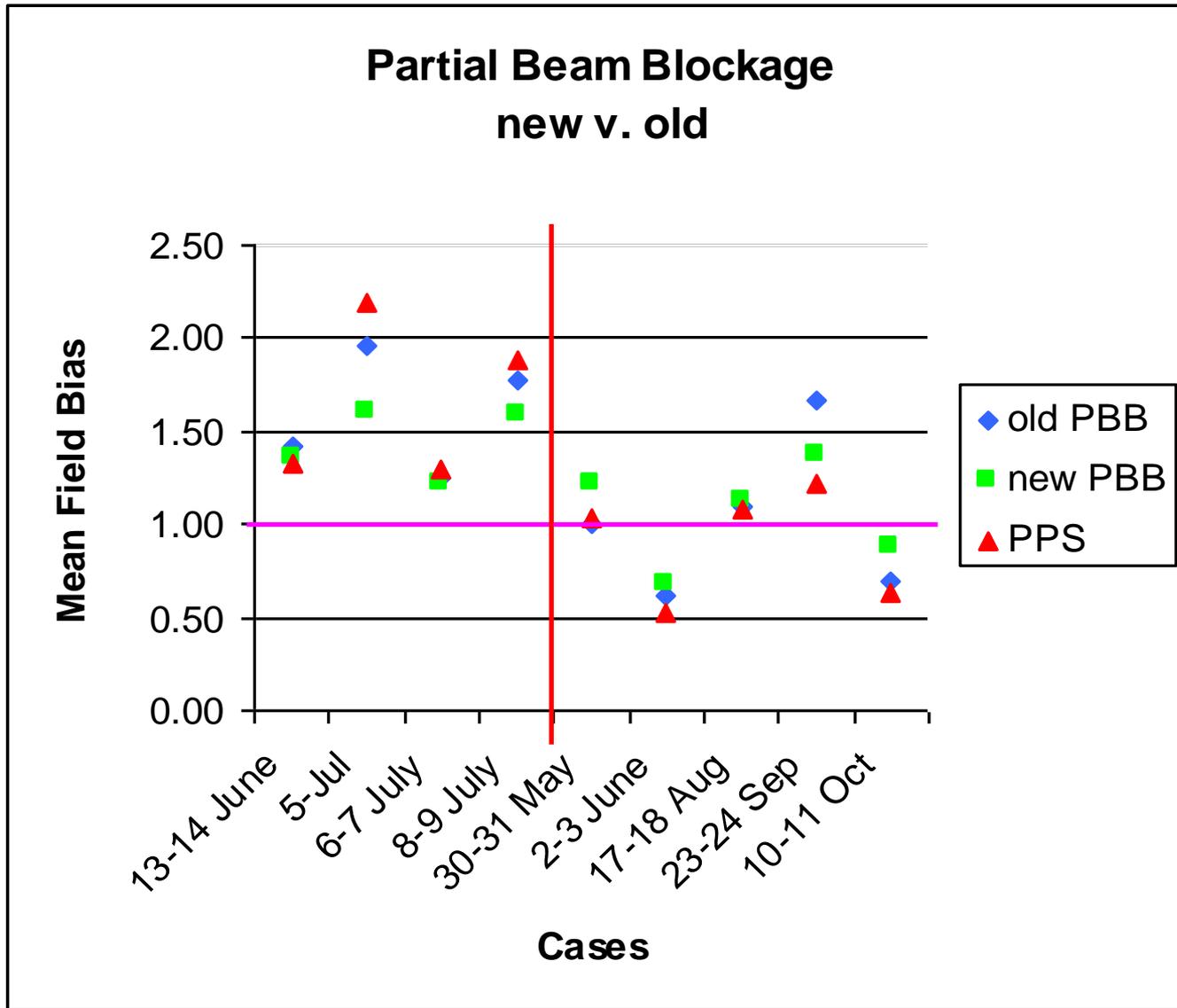
- Preliminary validation methodology
 - Ran each case twice: 1) old PBB logic & 2) new PBB logic
 - Used the KOUN cases, and KOUN blockage file
 - Gauges are from OK mesonet and micronets – didn't use gauges in non-terrain based blockages (water towers, etc.)
 - 4 'tropical' cases & 5 'continental' cases (of several hours each)
 - Used new $R(Z,Zdr)$ adaptable parameters
 - Stats: mean-field bias, fractional RMSE, correlation coefficient
 - Storm-totals results – all gauge-radar pairs for each case. Since storm-total results were similar, included hourly – gauge-radar comparisons
 - Hourly gauge-radar pairs are ≤ 150 km in range, as in past NSSL & OHD studies. Added "Overall" results (combined from all 9 cases)
 - PPS v. gauges provided for comparison

Cases & # of gauge-radar pairs

DP QPE Validation new v. old PBB	# gauge-radar pairs	
	storm-total	hourly (<150 km)
13-Jun-10	133	574
5-Jul-10	80	350
6-Jul-10	99	327
8-Jul-10	115	308
30-May-10	96	468
2-Jun-10	60	75
17-Aug-10	142	343
23-Sep-10	121	449
10-Oct-10	60	40
Totals	906	2934

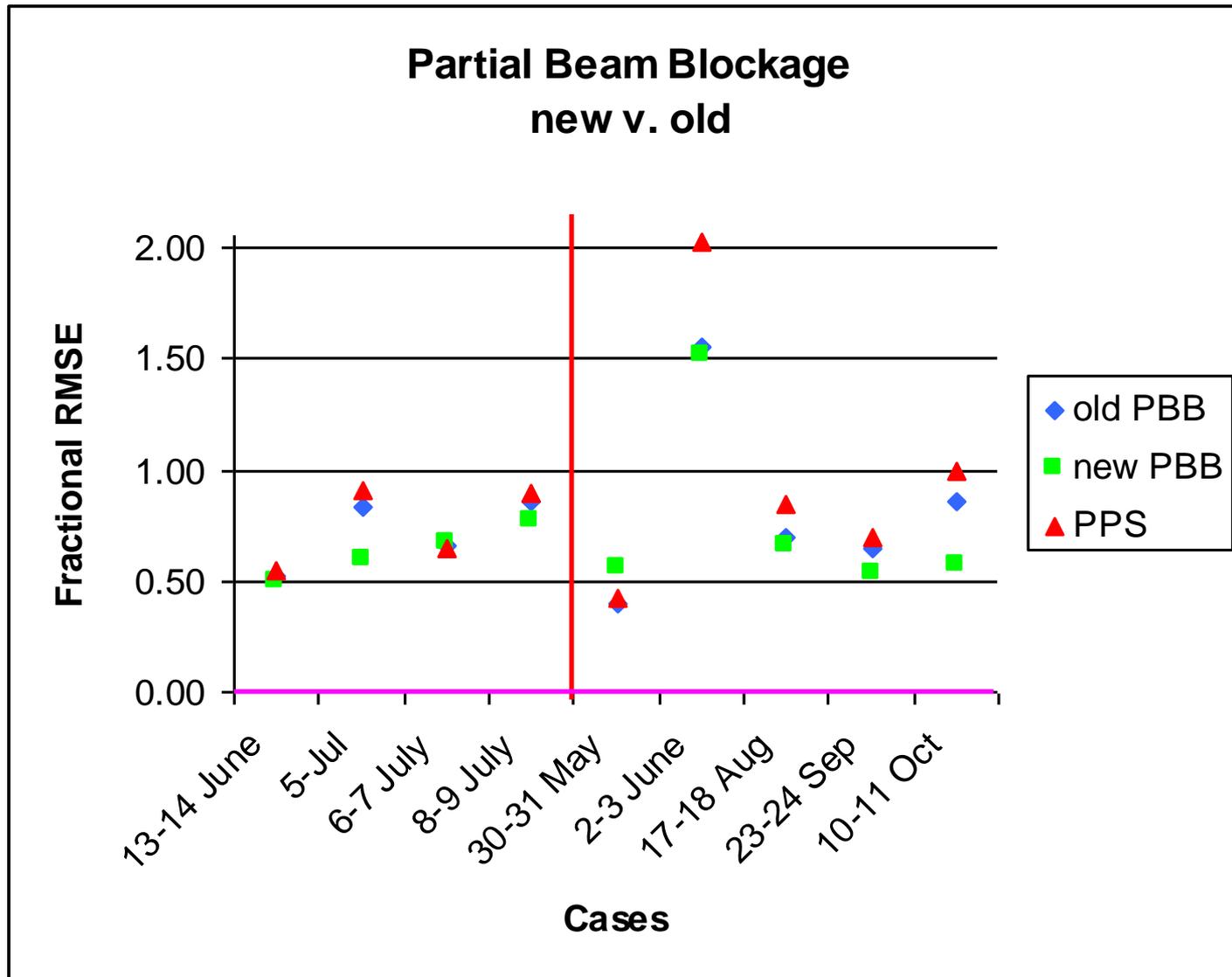
Number of gauge-radar pairs are from old PBB runs, and new PBB runs had the same number of pairs +/- 2. Differences are due using only non-zero DP QPE values. Tropical cases are in blue font.

Storm Totals – Mean Field Bias



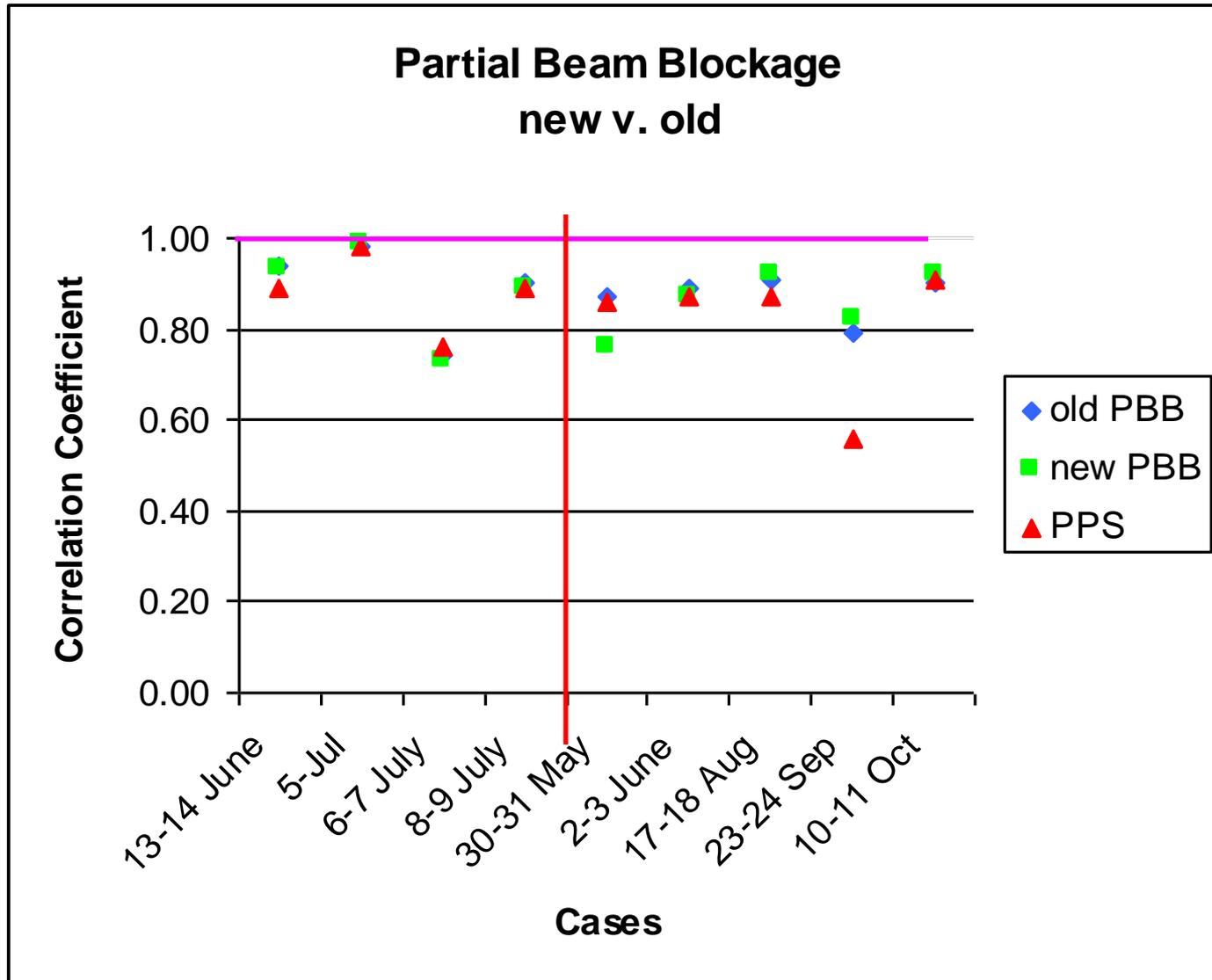
The best mean field bias value is 1.0 (magenta line). Great (lesser) values indicate underestimation (overestimation). Tropical cases are left of the red vertical line. ¹⁶

Storm Totals – Fractional RMSE



The best fractional RMSE value is 0 (magenta line). Tropical cases are left of the red vertical line.

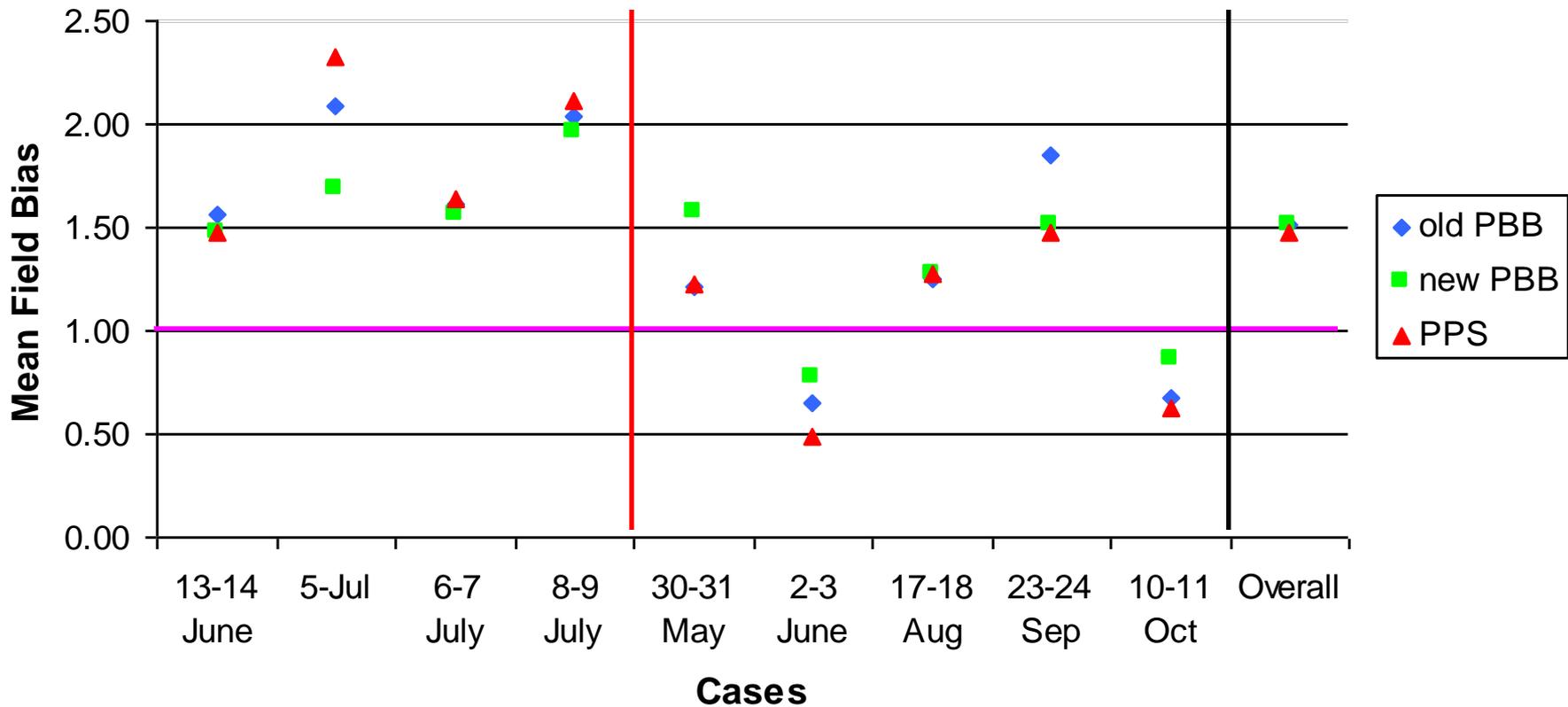
Storm Totals – Correlation Coefficient



The best correlation coefficient value is 1.0 (magenta line). Tropical cases are left of the red vertical line.

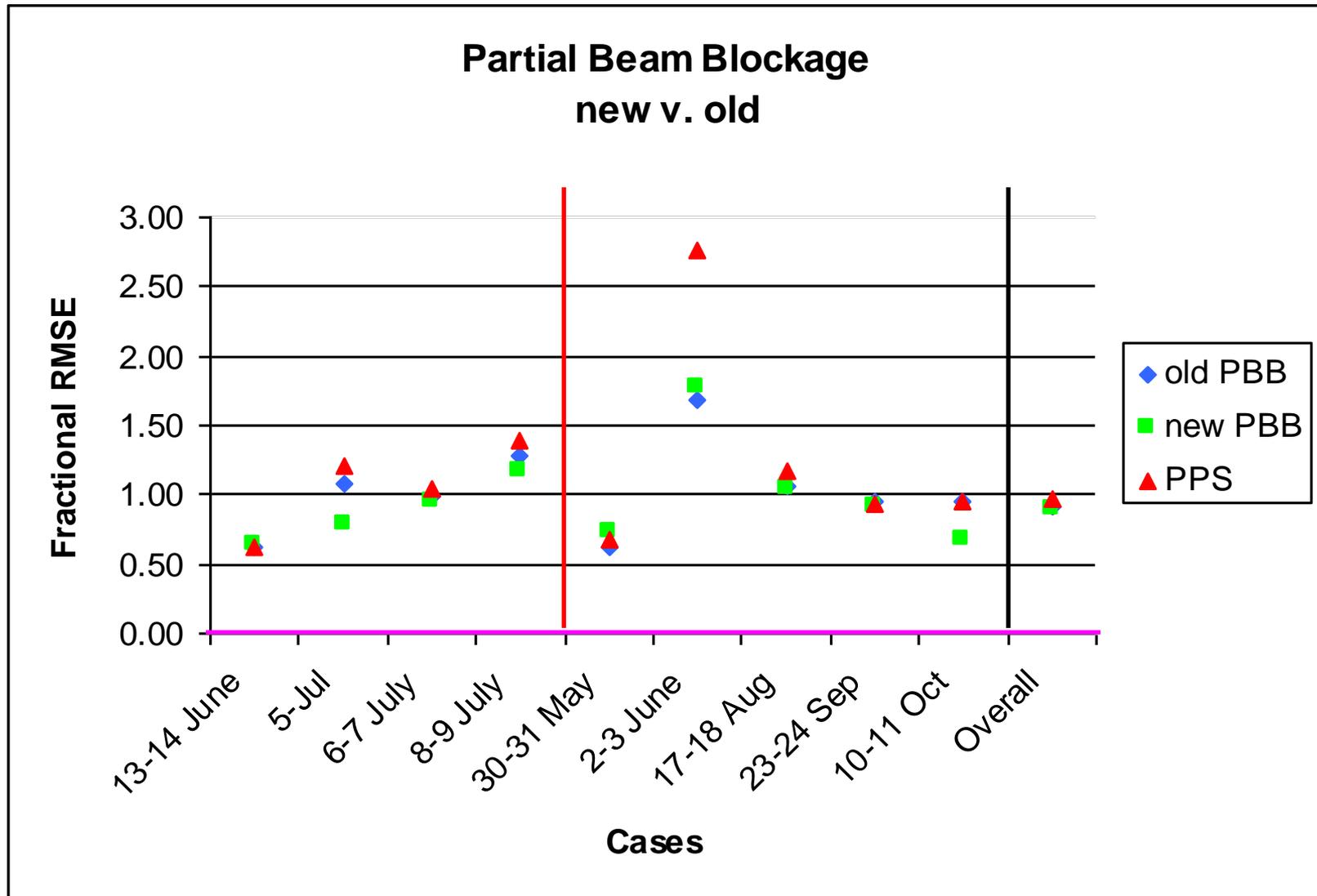
Hourly – Mean Field Bias

Partial Beam Blockage new v. old



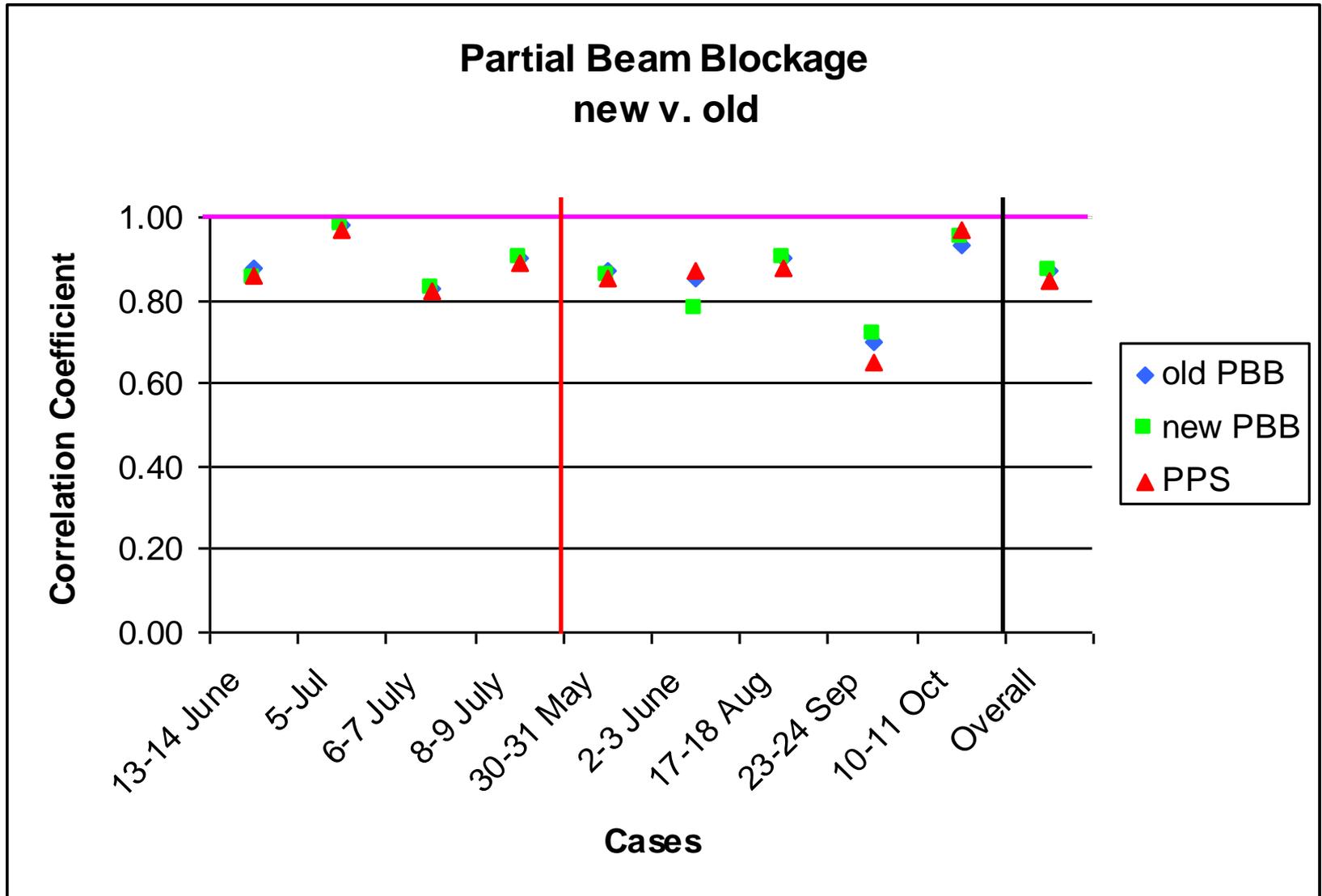
The best mean field bias value is 1.0 (magenta line). Great (lesser) values indicate underestimation (overestimation). Tropical cases are left of the red vertical line. ¹⁹

Hourly – Fractional RMSE



The best fractional RMSE value is 0 (magenta line). Tropical cases are left of the red vertical line.

Hourly – Correlation Coefficient



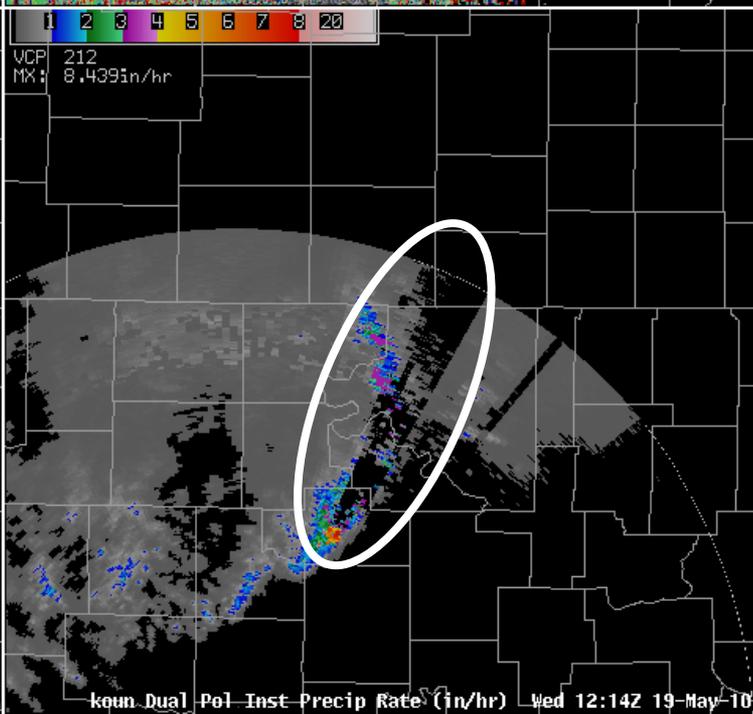
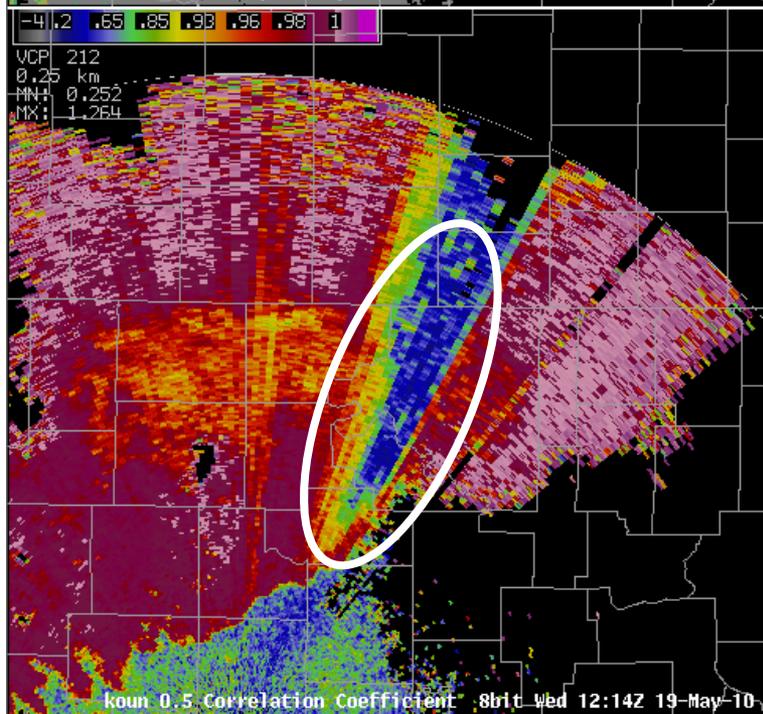
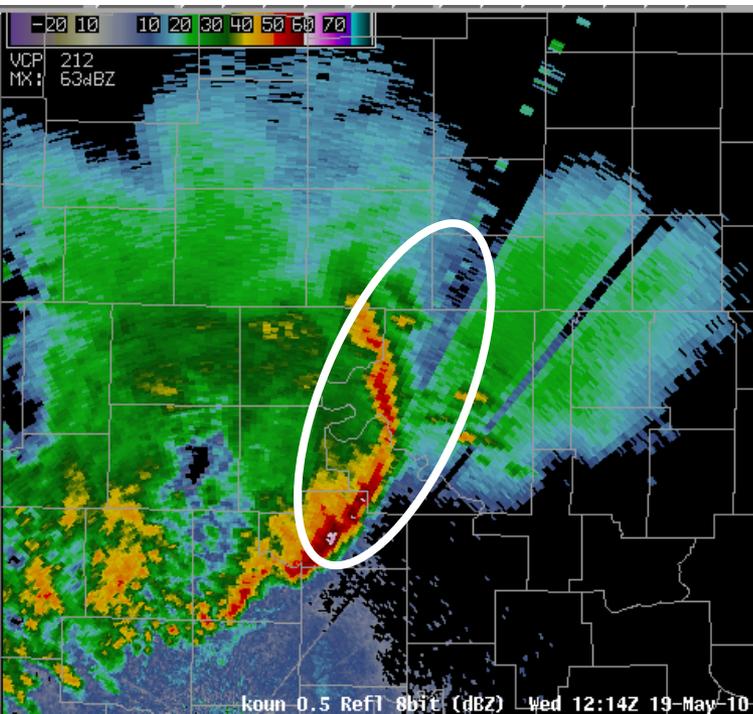
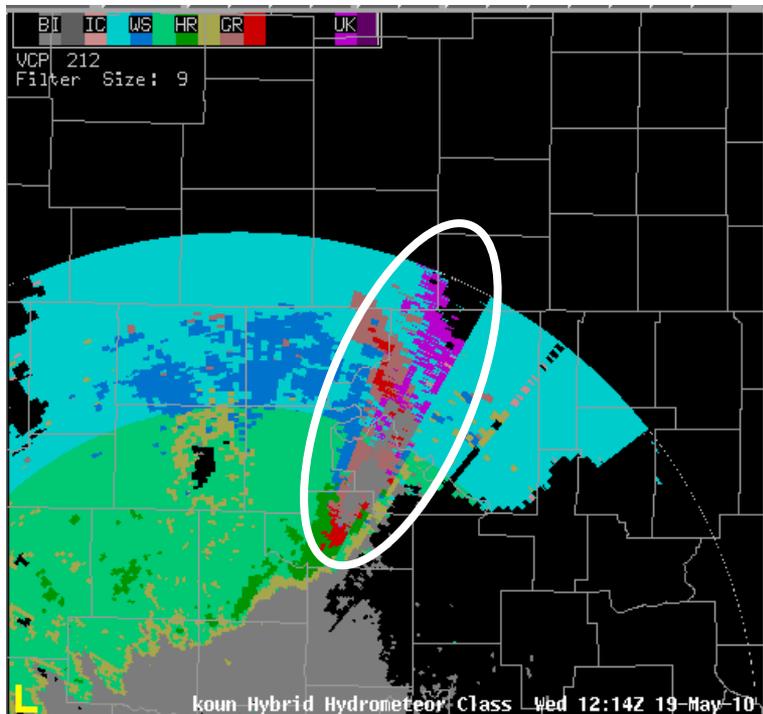
The best correlation coefficient value is 1.0 (magenta line). Tropical cases are left of the red vertical line.

New PBB conclusions

- **Preliminary results - Performance of the DP QPE at KOUN with the new PBB logic is at least as good as with the old PBB logic**
- **Secondary results – TBD, when dual pol data is available from WSR-88Ds in complex terrain**

3. Attenuation / NBF 'quick fix'

- Fix involves multiple Dual Pol algorithms
 - **Dual Pol Preprocessor** flags radials with attenuation and adds reflectivity – using conservative criteria
 - **Quality Index Algorithm** and **Hydro Classification Algorithm** add new rules
 - **DP QPE** within attenuation flagged radials
 - Removes RHO_{hv} check
 - Tries to compute rates based on hydro class - If not possible, tries R(Z,Z_{dr}), then R(Z), then R(K_{dp})
- 12 cases identified; preliminary results are positive. Needs more testing and optimization



Example of
severe
attenuation

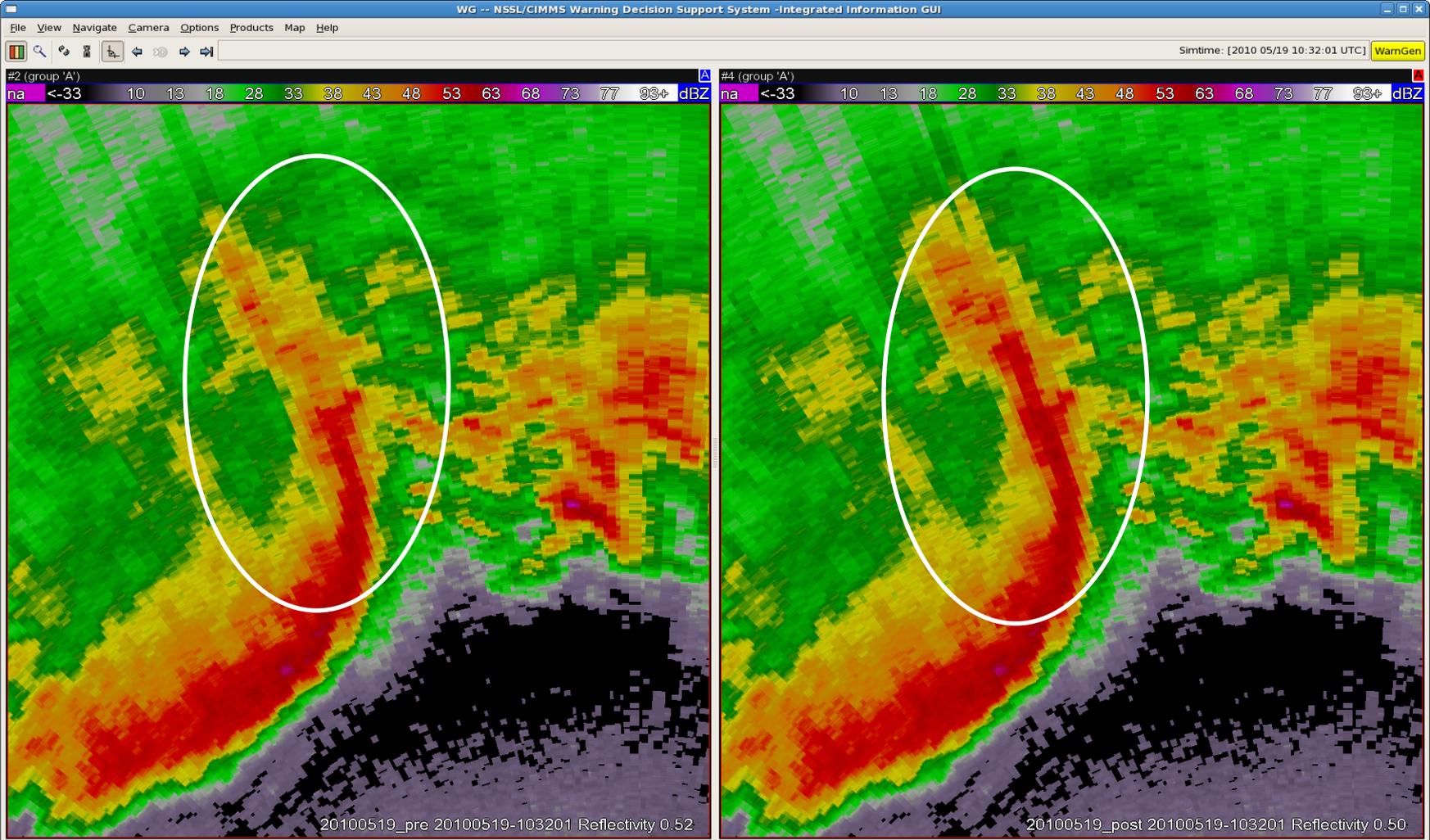
KOUN

19 May 2010

1214Z

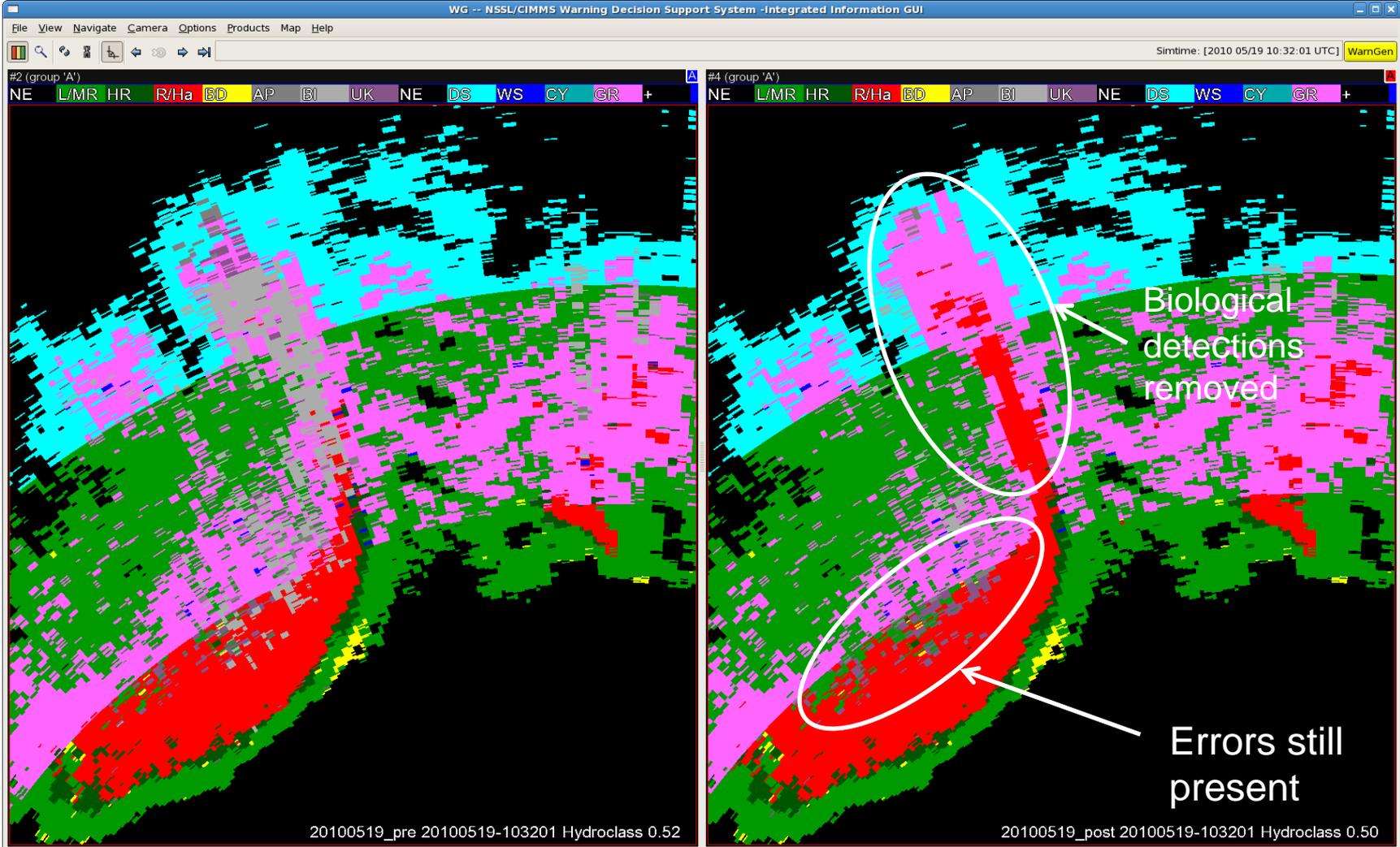
0.5 degrees

HHC	Z
CC	DPR



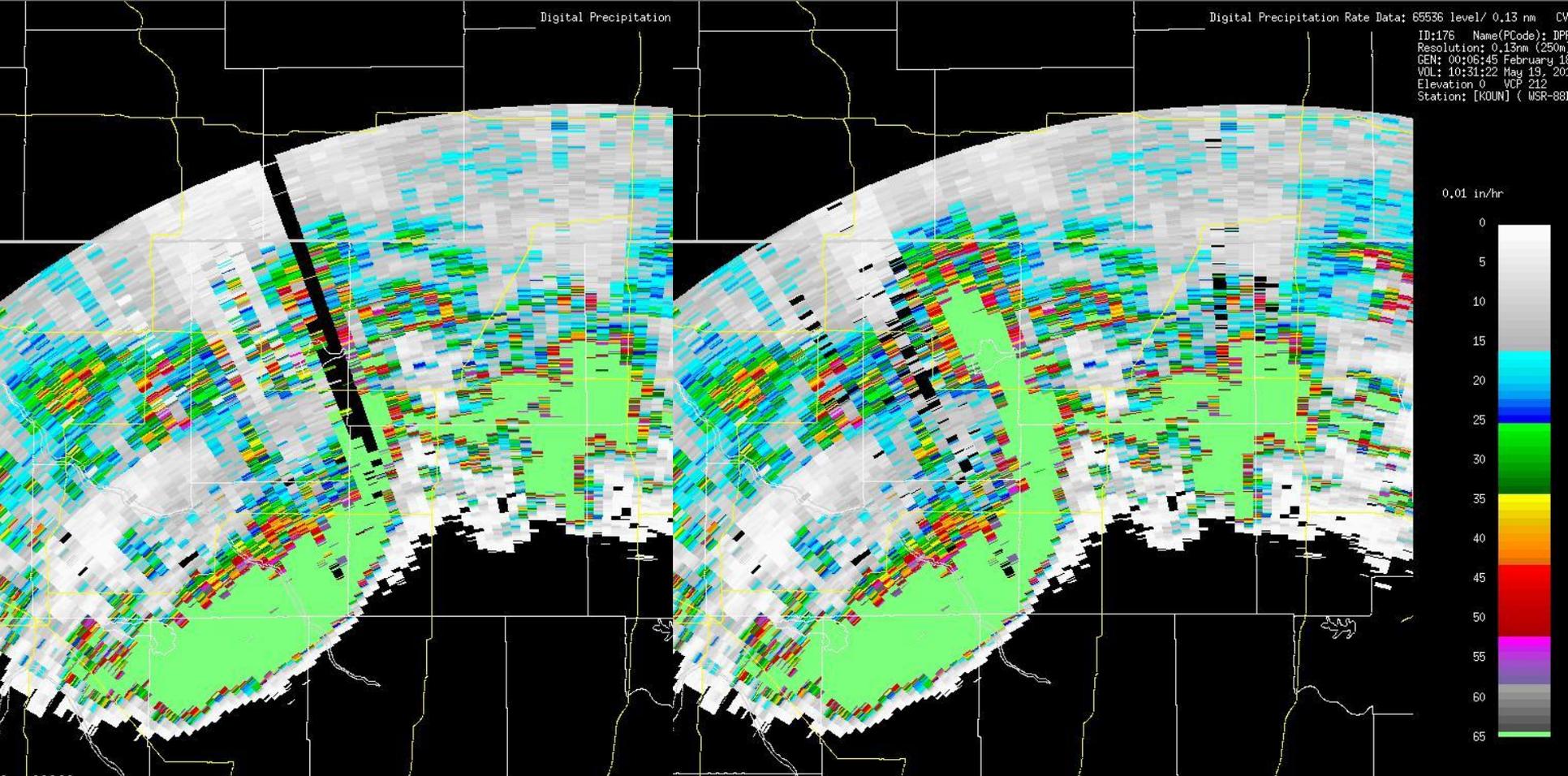
Reflectivity before and after correction 19 May 1032Z (from John Krause)

The additional reflectivity added to the north side of the line on the right hand side. This makes significant changes in all the hydro-class and rainfall rate products.



Hydro-classification before and after correction 19 May 1032Z (from John Krause)

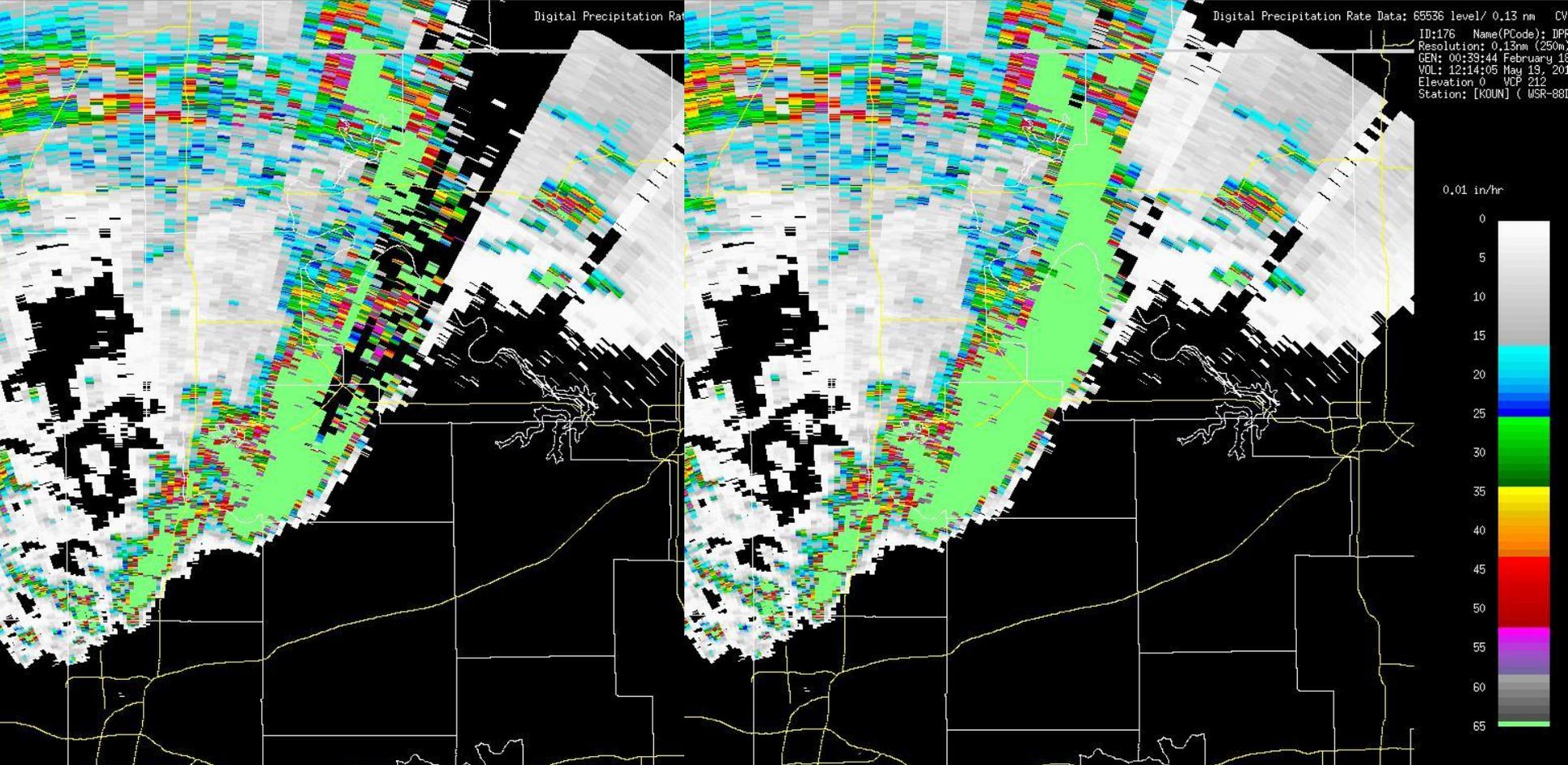
Most of the incorrect biological classifications (light grey) are removed where attenuation is properly detected, but there is some attenuation present on the NW side (near the melting layer) that is NOT detected and still have incorrect classification (grey = Ground Clutter). 27



DP QPE rates before and after

19 May 1032Z

(light green is ≥ 0.65 in/hr)



DP QPE rates before and after
19 May 1214Z
(light green is ≥ 0.65 in/hr)

Summary

- New $R(Z, Z_{dr})$ is better, but more evaluation is needed after Z_{dr} calibration issue is fixed
- **New PBB is okay at KOUN, but more evaluation is needed when dual pol data is available from WSR-88Ds in complex terrain**
- **Need to do more testing and optimization of Attenuation/NBF fix**

Acknowledgements

- NSSL, especially John Krause and Alexander Ryzhkov
- SEC, especially Mike Istok and Brian Klein
- ROC, especially Bob Lee, Dan Berkowitz, Rich Murnan, Steve Smith and too many to list
- WDTB, especially Paul Schlatter